

369/32 B27
 1. A method for determining a seek time required for moving a disk head between first and second addresses on a physical disk drive, said method comprising the steps of:

- 5 A) dividing the disk into a plurality of segments, each segment having a given size and being defined by first and second boundaries,
- B) establishing an array of seek times for seek operations between each segment pair based upon the first and second boundaries,
- 10 C) generating a seek time for disk head movement between the first and second addresses by interpolating the array based upon the first and second addresses.

2. A method as recited in claim 1 wherein said segment division includes dividing the physical disk drive into segments of equal size.

3. A method as recited in claim 2 wherein the segment boundaries and first and second addresses are independent of each other and wherein said seek time generation uses the first and second addresses as reference locations in each of

5 the logical blocks.

4. A method as recited in claim 3 wherein each reference is given relative to a predetermined position on the physical disk drive.
5. A method as recited in claim 1 wherein said seek time generation includes the step of generating a linear interpolation based upon the location of the first and second addresses relative to the segment boundaries.
6. A method as recited in claim 5 wherein said linear interpolation is based upon the Ratio Theorem analysis.
7. A method as recited in claim 6 wherein the physical disk drive includes a plurality of data blocks and said interpolation uses a center location for each data block as the reference location to obtain disk seek times for disk seek operations between different data blocks.
8. A method as recited in claim 6 wherein the physical disk drive includes a data block and said interpolation uses the boundaries of the data block to obtain a disk seek time for seek operations within the data block.

9. A method for determining the seek time for a physical disk drive configured to store data in a plurality of logical volumes over a time interval, said method comprising the steps of:

- 5 A) dividing the physical disk into a plurality of fixed sized segments independently of the logical volume configuration on the physical disk drive,
- B) determining seek times for seek operations between the segments,
- 10 C) accumulating statistics for each access to each logical volume during the time interval,
- D) converting the accumulated statistics into an estimated number of seeks between each pair of logical volumes,
- 15 E) defining a seek time for each logical volume pair based upon said segment seek times, and
- F) generating a total seek time as the sum of the products, for each logical volume pair, of the seek time for and the estimated number of seeks between
- 20 each logical volume in the logical volume pair.

10. A method as recited in claim 8 wherein said segment seek time determination includes the step of:

- 5 i) assigning a predetermined seek time for each,
 seek operation between two segment boundaries,
 and
 ii) calculating an intrasegment seek time based upon
 the predetermined seek times.

5 11. A method as recited in claim 10 wherein seek time
 determination includes the step of placing the
 predetermined seek times in a two-dimensional array with
 the rows and columns defined by the segment boundaries.

5 12. A method as recited in claim 9 wherein said accumulation
 of statistics includes segregating each access to a
 logical volume into one of predetermined classes of
 accesses and weighting the numbers of accesses in each
 predetermined class.

 13. A method as recited in claim 12 wherein said segregation
 of accesses is into one of random read, write and
 sequential prefetch read classes with weightings of 1.0,
 0.5 and 0.25, respectively.

 14. A method as recited in claim 13 wherein A_i and A_j
 represent the weighted access to logical volumes i and j ,

and A represents the weighted sum of all the accesses to the physical disk drive and wherein the estimated number of disk accesses for the logical volume pair being given by:

$$Nr\ seeks(i, j) = \frac{A_i A_j}{A}$$

15. A method as recited in claim 9 wherein said definition of seek time comprises determining the seek time between a center location of each of the logical volumes in the logical volume pair.
16. A method as recited in claim 15 wherein said definition of seek time includes interpolating the seek times determined for seek operations between the segments based upon the center locations.
17. A method as recited in claim 15 wherein said definition of seek time includes the step of linearly interpolating the seek times determined for seek operations between the segments based upon the center locations.
18. A method as recited in claim 15 wherein A_i and A_j represent the weighted access to logical volumes i and j , respectively, and A represents the weighted sum of all the

5 accesses to the physical disk drive and wherein the
estimated seek time for the logical volume pair is given
by:

$$\text{Seek time } (i, j) = t_{i,j} \frac{A_i A_j}{A}$$

19. A method as recited in claim 9 additionally comprising the step of determining the time for a seek operation within a logical volume.
20. A method as recited in claim 19 wherein said determination of intravolume seek time for a logical volume includes defining the boundaries of the logical volume relative to the segment boundaries and determining the seek time
5 between the logical volume boundaries.
21. A method as recited in claim 20 wherein said definition of intravolume seek time includes interpolating the seek times determined for seek operations between the segments based upon the logical volume boundary locations.
22. A method as recited in claim 20 wherein said definition of seek time includes the step of linearly interpolating the seek times determined for seek operations between the segments based upon the logical volume boundary locations.

- 532
506
23. A method for determining the seek time over a time interval for a physical disk drive configured to store data in a plurality of logical volumes, said method comprising the steps of:
- 5 A) dividing the physical disk into a plurality of fixed sized segments independently of the logical volume configuration on the physical disk drive,
- 10 B) determining seek times for seek operations between the segments by assigning empirically derived seek times between two segment boundaries,
- 15 C) accumulating statistics for each access to each logical volume during the time interval,
- D) converting the accumulated statistics into an estimated number of seeks between each pair of logical volumes by weighting the numbers of accesses in each of different predetermined classes,
- 20 E) defining a seek time for each logical volume pair based upon said segment seek times by using the center locations of each logical volume to interpolate the seek times determined for seek operations between the segments, and
- 25 F) generating a total seek time that is the sum of the seek times for each logical volume pair obtained as a function of the estimated number of seeks and the defined seek time for the logical volume pair.

24. A method as recited in claim 23 wherein each of said center locations is given as an offset from a segment boundary according to:

$$p = x - \lfloor x \rfloor$$

5 and

$$q = \lceil y \rceil - y$$

25. A method as recited in claim 24 wherein said definition of seek time for each logical volume includes the step of generating a seek time according to:

$$\begin{aligned} t_{i,j} = & pq \text{ time}(\lfloor x \rfloor + 1, \lceil y \rceil - 1) \\ & + p(1-q) \text{ time}(\lfloor x \rfloor + 1, \lceil y \rceil) \\ & + (1-p)q \text{ time}(\lfloor x \rfloor, \lceil y \rceil - 1) \\ & + (1-p)(1-q) \text{ time}(\lfloor x \rfloor, \lceil y \rceil) \end{aligned}$$

26. A method for determining the seek time over a time interval for a logical volume on a physical disk drive configured to store data in at least one logical volume, said method comprising the steps of:

- 5
- 10
- 15
- 20
- A) dividing the physical disk into a plurality of fixed sized segments independently of the logical volume configuration on the physical disk drive,
 - B) determining seek times for seek operations between the segments by assigning empirically derived seek times between two segment boundaries,
 - C) accumulating statistics for each access to the logical volume during the time interval,
 - D) converting the accumulated statistics into an estimated number of seeks between locations within the logical volume by weighting the numbers of accesses in each of different predetermined classes,
 - E) defining a seek time for the logical volume pair based upon said segment seek times by using the boundary locations of the logical volume to interpolate the seek times determined for seek operations between the segments, and
 - F) generating a total logical volume seek time that depends upon the number of accesses to the logical volume and the seek times between the boundary locations for the logical volume.

- 25
27. A method as recited in claim 26 wherein each of the boundary locations is given as an offset from a segment boundary according to:

$$p = x - [x]$$

and

$$q = \lceil y \rceil - y$$

5

28. A method as recited in claim 27 wherein said definition of seek time for intravolume seeks includes the step of generating a seek time according to:

$$t_{i,j} = pq \text{ time}(\lfloor x \rfloor + 1, \lceil y \rceil - 1)$$

$$+ p(1-q) \text{ time}(\lfloor x \rfloor + 1, \lceil y \rceil)$$

$$+ (1-p)q \text{ time}(\lfloor x \rfloor, \lceil y \rceil - 1)$$

$$+ (1-p)(1-q) \text{ time}(\lfloor x \rfloor, \lceil y \rceil)$$